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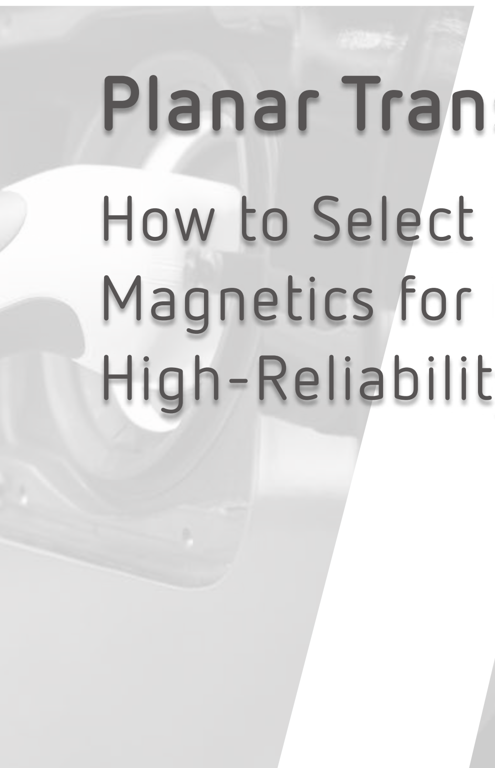
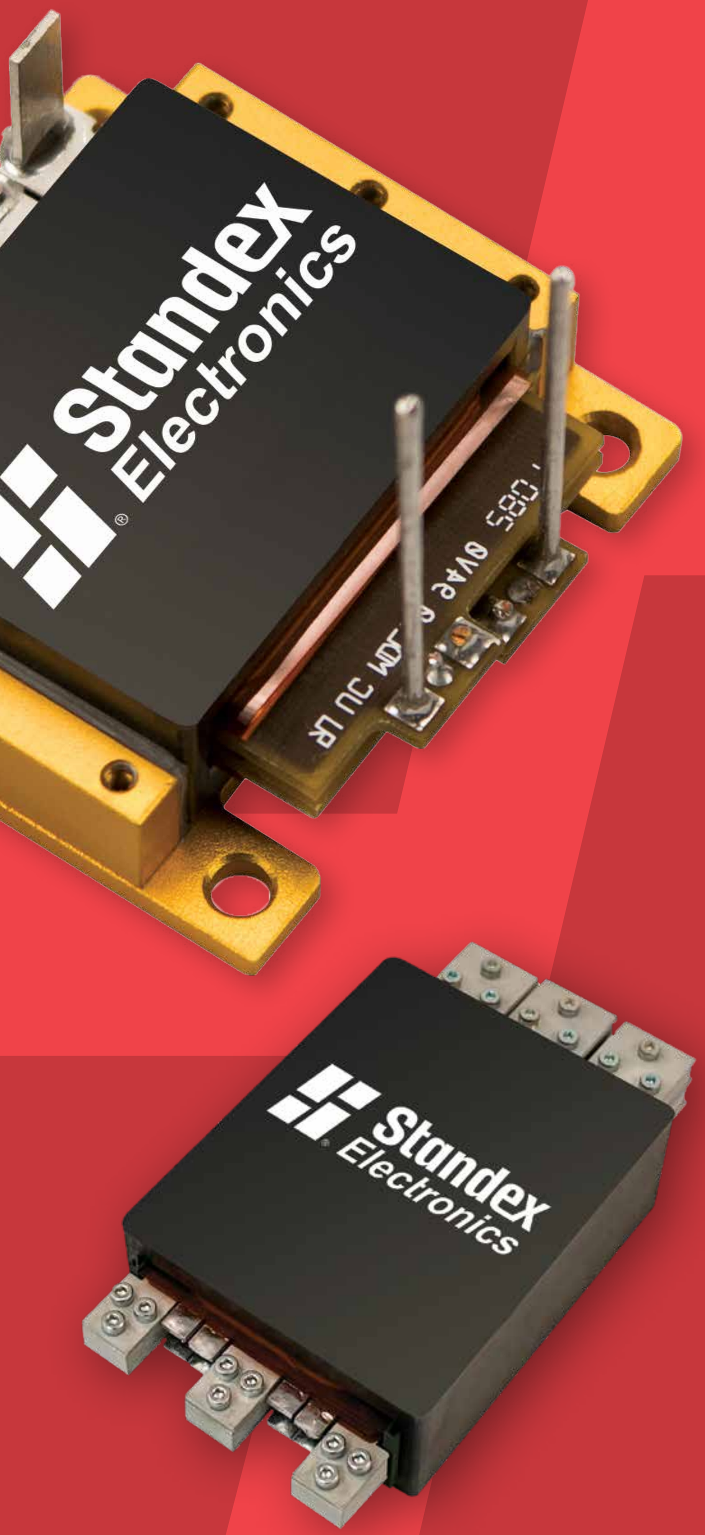


Planar Transformers

How to Select Planar Magnetics for Low-Profile, High-Reliability Designs



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How to Select Planar Magnetics for Low-Profile, High-Reliability Designs

Introduction

Advances in electronics continue to push the limits of size, form factor, and feature density in many products. Many advanced areas of electronics require unique power system designs to ensure stable, noise-free power delivery and regulation. In the realm of high reliability electronic designs, a new set of challenges exists alongside the need for low noise, low profile, and high power density. Thermal management challenges also arise in power systems with high power density, including within magnetics components used for high-current power delivery.

It's easy to overbuild a system to try and ensure mechanical or thermal reliability, but advanced power systems need to have a low profile so that the system can achieve size, weight, and performance (SWaP) targets. In advanced power systems, one of the important areas in a design that can be targeted to reduce the device profile are magnetics. In addition to capacitors and connectors, magnetics components tend to be some of the bulkiest and heaviest components in a power system, yet their reliability challenges range from excess vibration to excessive losses during high power operation. Hitting SWaP targets requires an alternative set of components that can help ensure reliability while providing a low profile alternative to traditional off-the-shelf magnetics components.

Planar transformers are an excellent alternative class of components compared to typical board-mounted transformers and inductor coils. Planar magnetics have a unique structure that provides low profile without sacrificing power delivery or incurring additional costs. The low profile of these components creates other advantages for advanced power systems, particularly from the view of power conversion efficiency, heat management, and mechanical vibration. These characteristics are just a few points that should be considered when selecting planar magnetics, especially for high reliability designs. Target application areas for these components span from industrial equipment to aerospace and automotive, all of which carry strict reliability standards.

Selecting Reliable Planar Magnetics

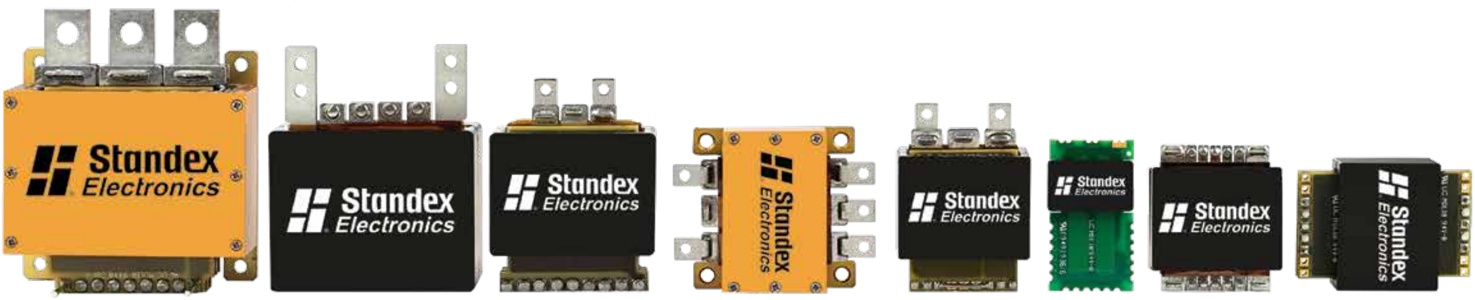
Selection of planar magnetics should begin by considering the various advantages of these components. Certain systems can benefit from the low profile and low weight provided by planar magnetics. A low profile option gives designers the ability to better utilize space in their systems, and properly chosen planar magnetics can ensure higher reliability compared to traditional magnetics for power systems.

Important Advantages in High Reliability Systems

The low profile construction of planar magnetics provides the following advantages in terms of mechanical, thermal, and electrical reliability:

Mechanical vibration - The low profile and lower weight of planar magnetics makes them less susceptible to low-frequency vibrations that can damage bulky components. This is particularly important for board-mounted transformers, where vibration in off-the-shelf components can create significant stress on solder joints.

Mechanical shock - Planar magnetics have a modular, stackable structure that eliminates empty space in the component body. In addition to being desirable for preventing damage from vibration, these components can better withstand mechanical shock.



Heat dissipation - Planar magnetics have an exposed surface with large area that allows direct attachment of a heat sink to the package as needed. In custom components, a heat sinking element could be built into the packaging. This aids convective heat transfer away from the system, and it makes cooling with forced airflow more effective.

Power conversion - The compact structure of planar magnetics ensures less flux leakage in power conversion and regulation applications. Fewer wire turns are needed in these components to provide the required inductance and flux confinement, leading to lower DC losses. Both points help ensure planar magnetics can provide high power conversion efficiency.

For these reasons, planar magnetics components are often targeted for high reliability applications, where mechanical disturbances and thermal management in low profile enclosures are the primary challenges to be solved. Different industries have their own sets of challenges and application areas that can be addressed with planar magnetics.

Target Industries and Applications

The major application area for planar magnetics is in high power conversion (AC/DC or DC/DC) and power regulation, making planar magnetics candidates for use in a variety of systems. Three of the major application areas for planar magnetics include the following areas.

Aerospace power systems - Planar magnetics in aerospace systems must support power delivery at high current in a low profile package. EMI can also be problematic in aerospace electronics due to the cramped environment, where power conversion/regulation modules are often housed alongside low-level digital components. Some of the important specifications for these systems are rated switching frequency, parasitics (DC resistance and capacitance), and inductance values as these will be the main factors driving power conversion efficiency. A lower profile with lower weight is also preferred to help meet SWaP goals.

Industrial equipment - This category spans a broad range of products that may require a dedicated power converter and regulator module. Some equipment like power tools, power distribution equipment in facilities, and industrial robotics require high space utilization without sacrificing power density or efficiency during operation. Planar magnetics are the preferred platform for low-profile power conversion in this area as these magnetics aid high space utilization as well as high power conversion efficiency in industrial power systems. The important specifications in this area are size and power handling, particularly z-axis height.

Automotive power electronics - As a greater portion of the vehicle fleet become electrified, vehicles and their charging stations are incorporating unique regulator topologies. Power systems in vehicles need to have low weight and high space utilization while implementing functionality like multi-phased regulation, multi-level operation, and low frequency envelope tracking. Magnetics in these systems also need to operate with high peak currents, which places more focus on thermal and Di/Dt losses. Some of the important specifications on automotive planar magnetics include their electrical characteristics as these will be the major determinant of thermal management demands and design reliability.

Understanding Planar Magnetics Specifications

Clearly, reliability means different things in different systems and industries, with certain planar magnetics specifications taking focus in different applications. Here are some of the main planar magnetics specifications that impact reliability:

Voltage limitations – Similar to their wire-wound counterparts, planar transformers are designed to accommodate certain input and output voltage and current ranges. These need to be considered when planar magnetics are used in high reliability power systems to optimize transformer size. In addition, transformers should provide high isolation between primary and secondary sides of the component to prevent breakdown and ensure safety.

DC winding resistance - The winding resistance influences the efficiency of a planar transformer or inductor. These resistive losses impact how the part will heat up during operation. Ideally, DC winding resistance in these components should be as low as possible.

Heat dissipation - This actually relates to the aspect ratio of the component, which will limit the size of heat sink that can be attached to the packaging. Some planar magnetics could have their heat sinks built into the package which can provide greater mechanical reliability than a simple adhesive-attached heat sink.

Current limit - The DC winding resistance and heat dissipation method will influence the current limit in planar magnetics. For power conversion systems, particularly in those for regulating DC power, the current limit is often specified as a rectified DC value.

Switching frequency limit - When used in power conversion and regulation, planar magnetics will have some frequency limit that is determined by their parasitics and average power dissipation limit. Typical values for high current planar magnetics are on the order of 100 kHz-1 MHz, which may leave some residual ripple if used in a switching regulator. There may also be a duty cycle limit as this will determine the average power dissipation.

Mounting style - Options for planar magnetics include through-hole, SMT, tab mounting, or card mounting to a board or its enclosure. The mounting style determines the ability of a system to withstand mechanical vibration during operation. In terms of vibration resistance and mechanical shock, through-hole mounting is most reliable, and it is preferred in areas like defense and aerospace. RMS currents will typically dictate what types of mounting styles are acceptable.

Lumped capacitance - This is important with regard to noise coupling in switching regulators, industrial power systems, and other mixed-signal equipment. It also sets the limits of switching frequencies in power regulators. Ideally, lumped capacitance should be low so as not to create low-impedance paths for noise or ESD.

Leakage inductance - This value reflects the extent to which the magnetic field is confined in the coil of a magnetic component. In a transformer, it accounts for imperfect transfer of magnetic flux between the primary and secondary coil. A low leakage inductance is related to higher power conversion efficiency.

Summary on Planar Magnetics Selection

The process for selecting planar magnetics is similar to that for other high-reliability components in power systems. Input/output power limits are compared to power handling requirements, and these are used to narrow down the list of candidate components for use in a new design. Other factors like space utilization may be more important in something like automotive or industrial equipment, while thermal reliability and vibration resistance may be more important for areas like aerospace. In any case, reliable power systems design requires considering the major factors that could cause a product to fail once deployed. Planar transformers offer an innovative solution to many of those common problems in automotive, aerospace, industrial systems, energy, and many other areas.

Designers who are considering using planar magnetics in their power system designs should consider the broad line of planar magnetics products from Standex. The planar transformer and inductor options from Standex are designed to provide high efficiency power conversion and regulation with high power and current limits in power system designs. Contact Standex today to learn more about its line of high power, high reliability planar magnetics components.

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